

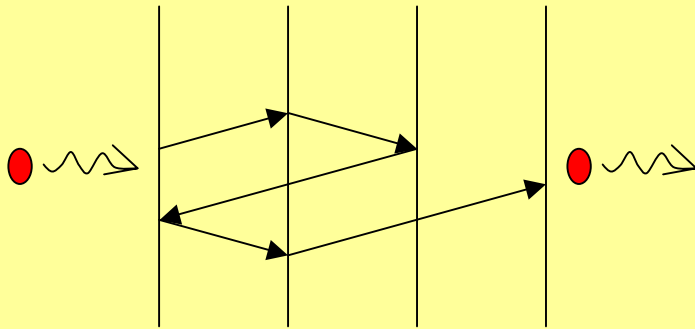
All Optical Network Research at UIUC

- **Grating optical buffers**
S. L. Chuang - Supported by NSF
- **Low-chirp QW+QD coupled lasers**
Nick Holonyak, Jr. and Norman Cheng
- Supported by ARO and DARPA
- **All optical, wavelength selective $1 \times N$ optical switch**
Milton Feng

Grating Optical Buffers*

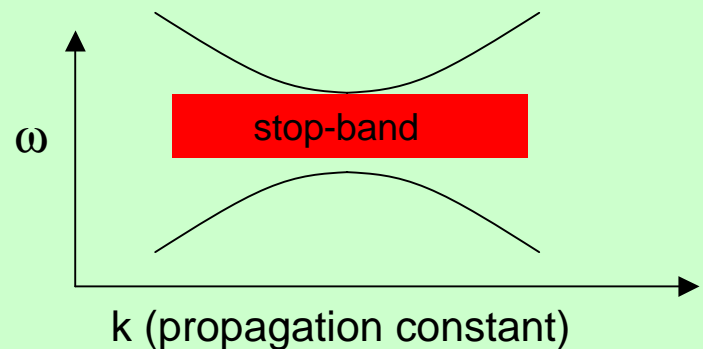
PI- S. L. Chuang, UIUC and Chang-Hasnain (UCB) (Supported by NSF)

Intuitive picture: light bounces back and forth before exiting



- Use gratings or photonic crystals for slow light structure designs.
- Trade-off between slow-down factor and bandwidth.

Dispersion relation shows the slow-down

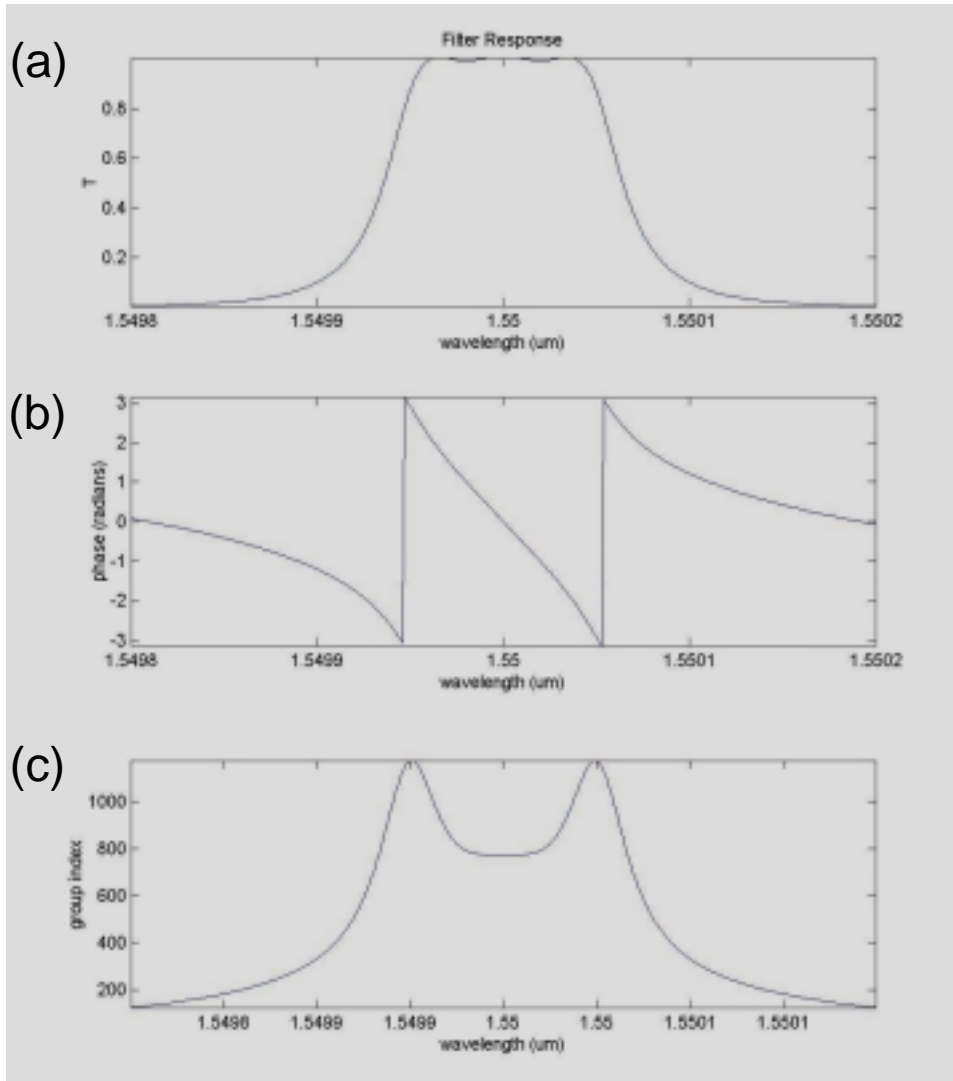


Graph: delay near stop-band of a Bragg grating

$$v_g = \frac{\partial \omega}{\partial k} \quad (\text{slope of the band})$$

Group velocity reduced at band edge

Phase-shifted Bragg Gratings



Schematic layer structure



The graphs on the left represent a response of cascaded phase-shifted Bragg gratings

(a) Transmission is fairly flat over ~10 GHz (0.08 nm @ 1550 nm).

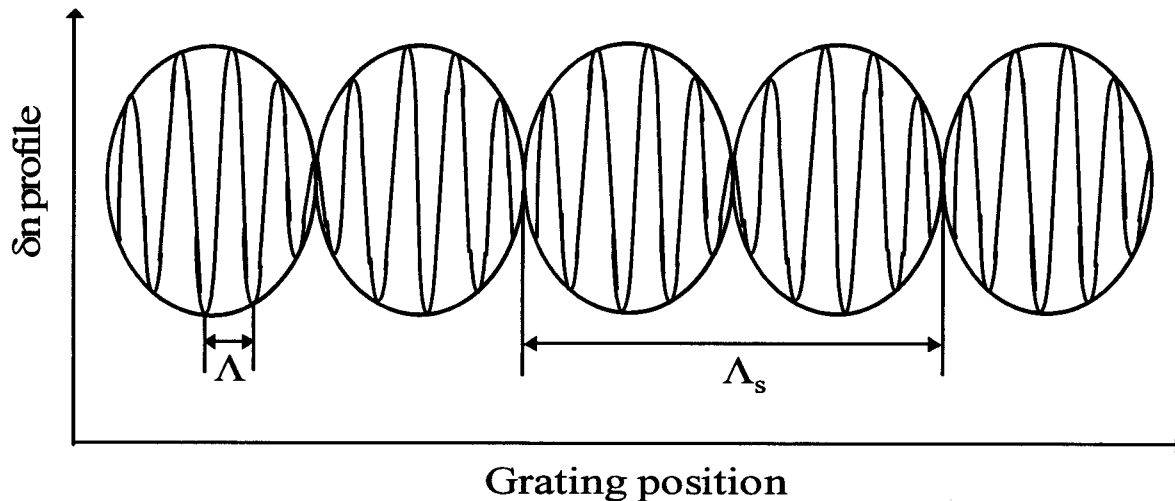
(b) Phase response – steep, nearly linear – results in large slow-down factor over the bandwidth.

(c) Group index is increased by a factor of more than 200.

Such a reduction over the sizable bandwidth was achieved by assuming high index contrast, which will be realized using semiconductor and oxide layered gratings.

Slow-wave Gratings

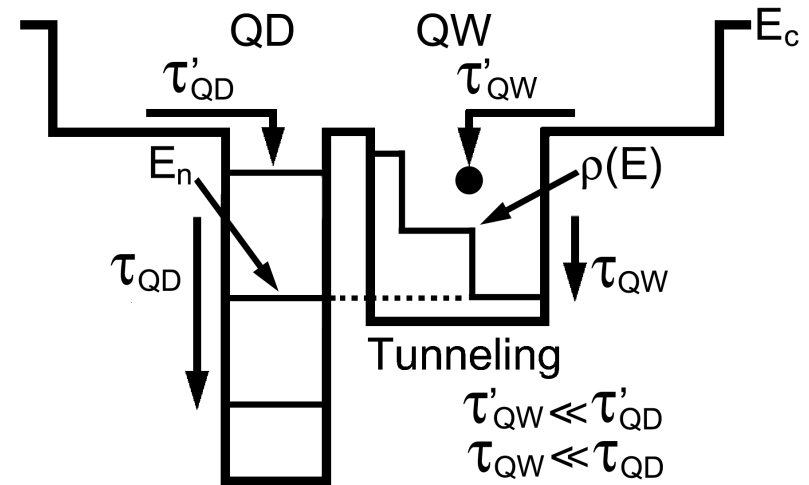
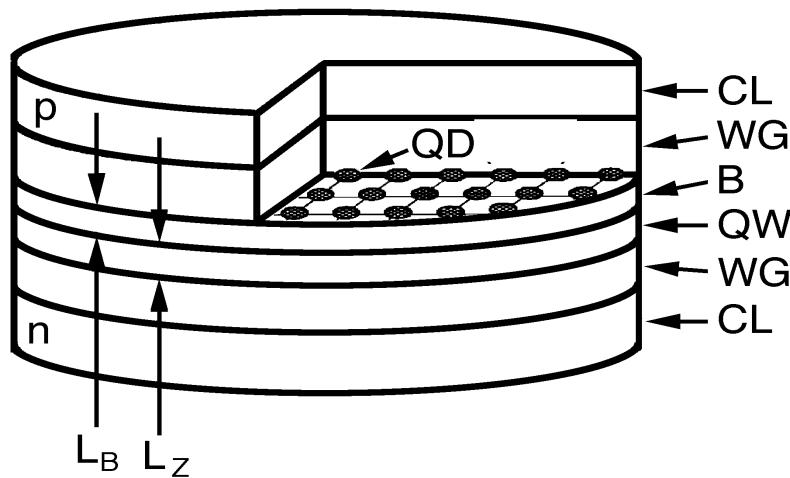
Moiré grating
$$n(x) = \tilde{n} + \partial n \cos \frac{2\pi}{\Lambda_s} z \cos \frac{2\pi}{\Lambda} z$$



- A few types of gratings can be used (I.e. Moiré grating and photonic crystals)
- Fabrication: epitaxial growth, etched gratings, or novel in-plane oxide gratings
- Variable control: current injection into the semiconductor layers
 - phase shifts or index contrast changes

Coupled Quantum Dot and Quantum Well (QD+QW) Lasers

Nick Holonyak, Jr., UIUC



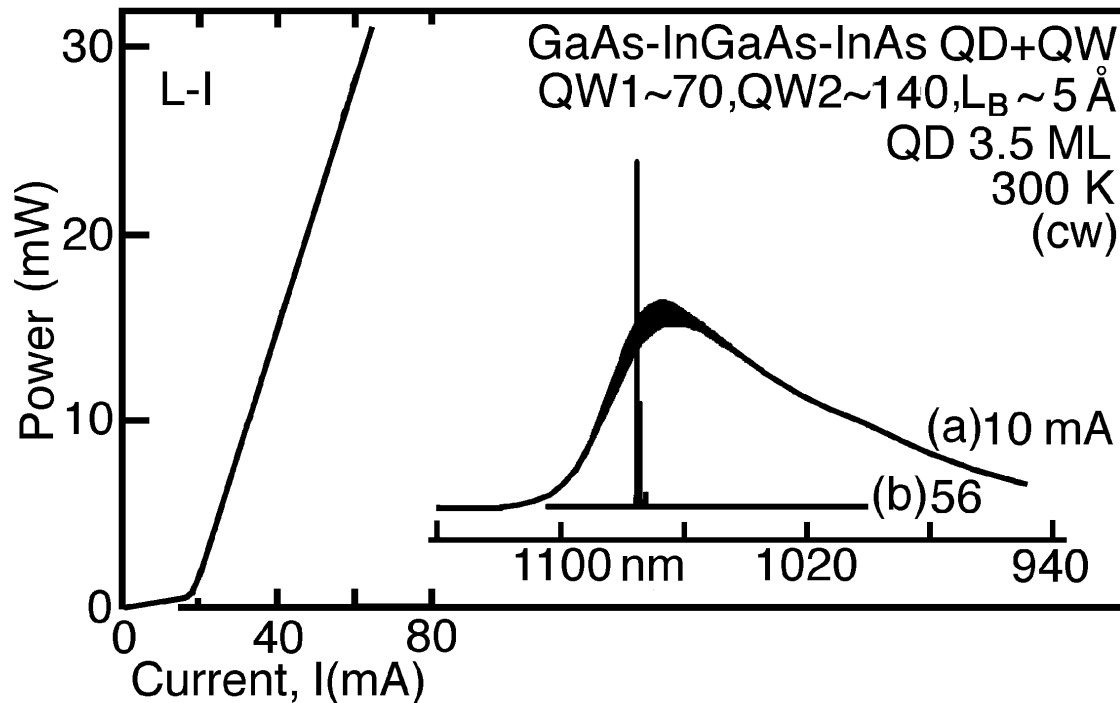
The QW coupled to QDs is used as

- Energy selection and filtering
- Carrier recycling
- Carrier storage and supply



- High quantum efficiency
- Low chirp
- Ground state emission

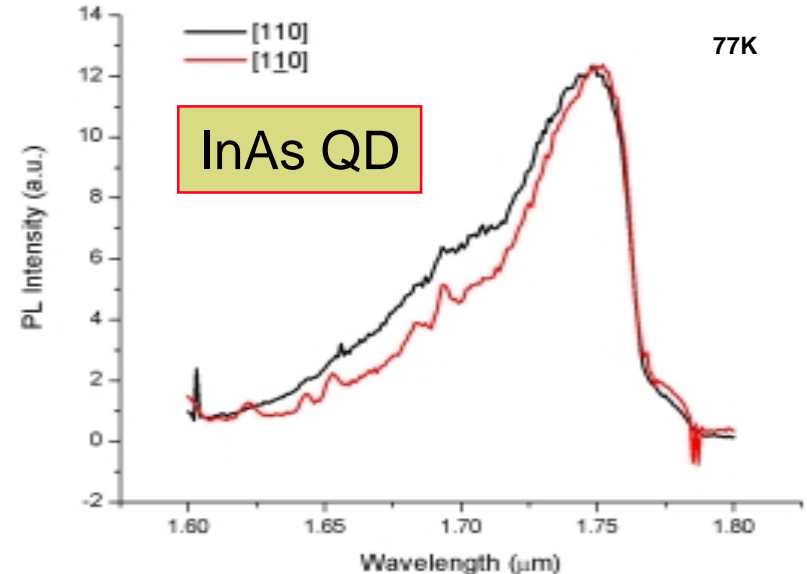
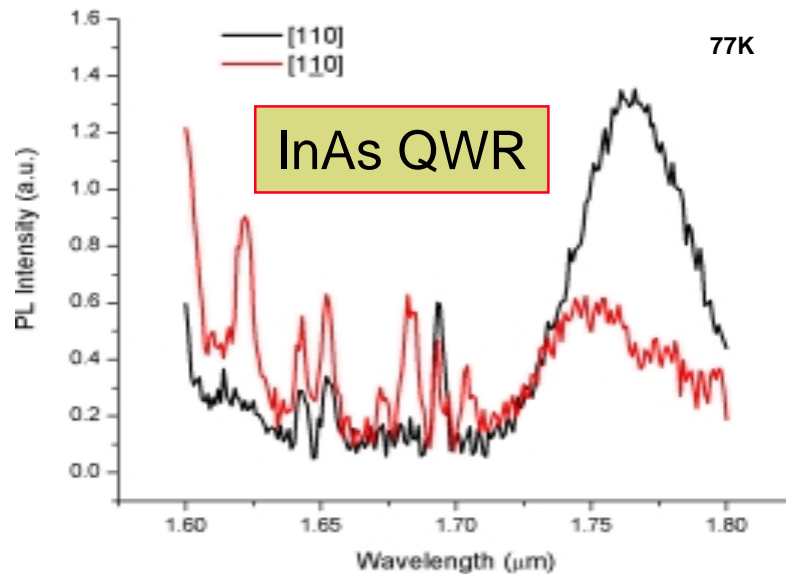
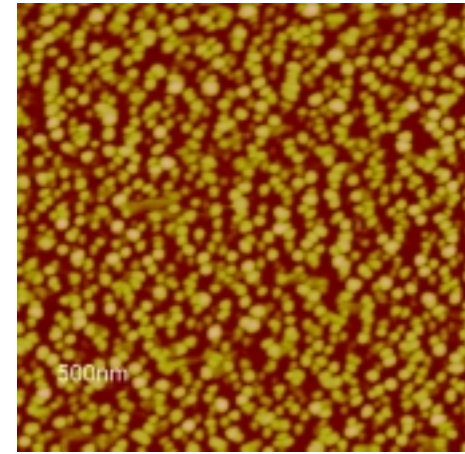
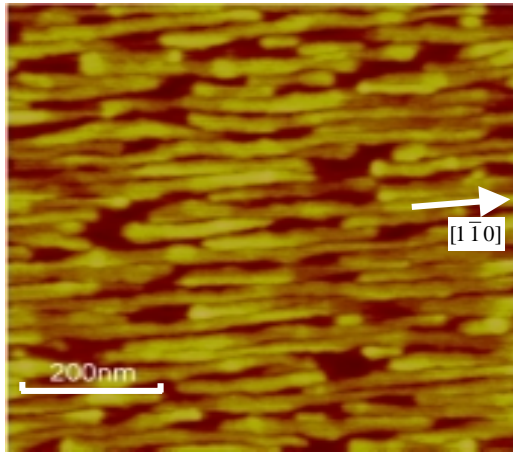
1.1 μm QD+QW Laser Characteristics



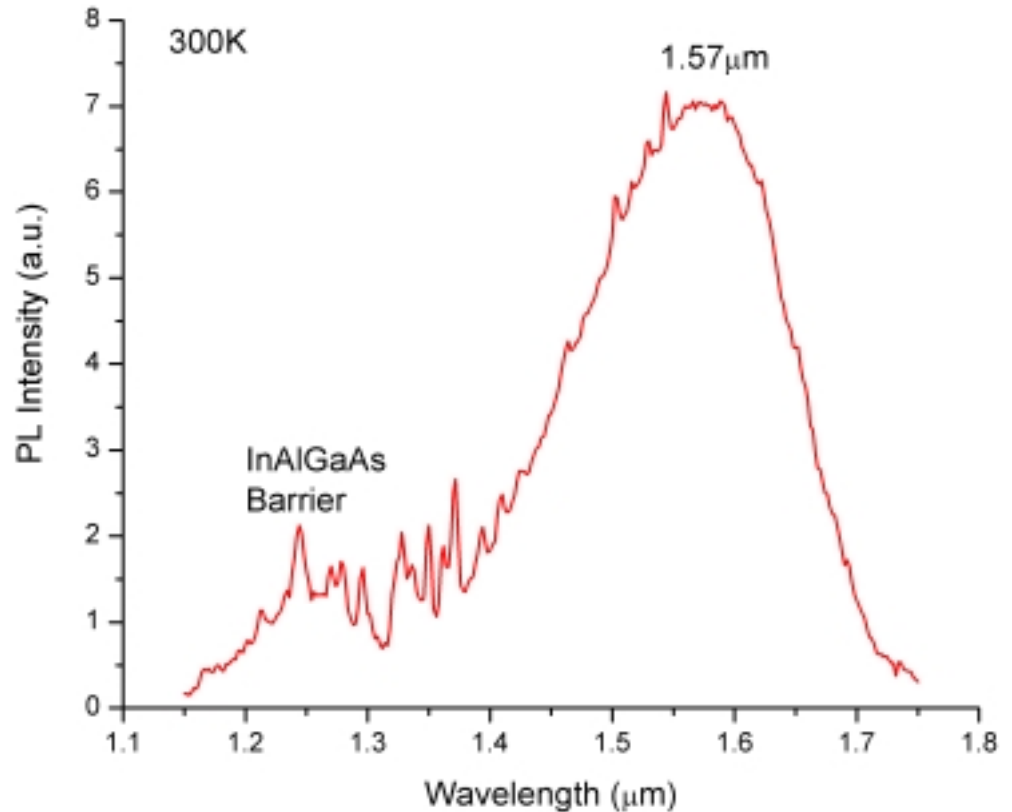
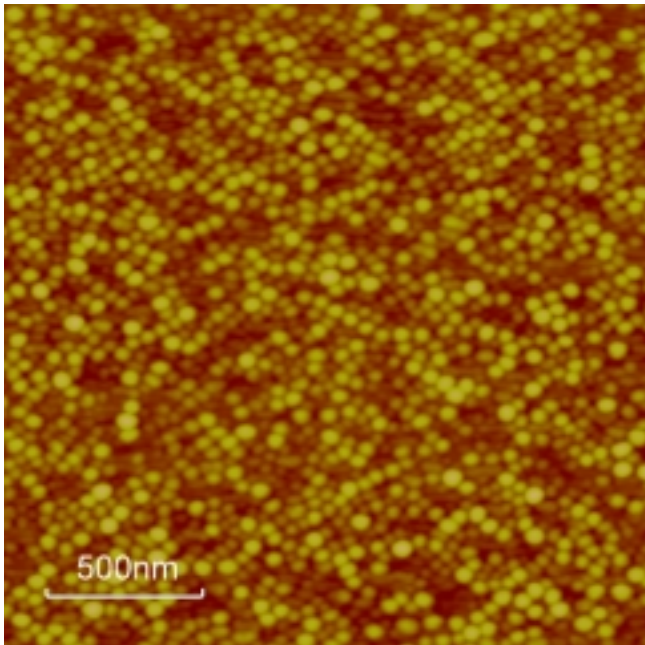
- Single InAs QD layer coupled to an InGaAs QW via a 5 \AA GaAs barrier
- Short cavity length ($290 \mu\text{m}$) and high output power ($> 50 \text{ mW}$)
- Ground state emission
- Extreme low chirp (an order of magnitude smaller than the QW lasers).

InAs Quantum Wires on InP Substrate

Norman Cheng, UIUC



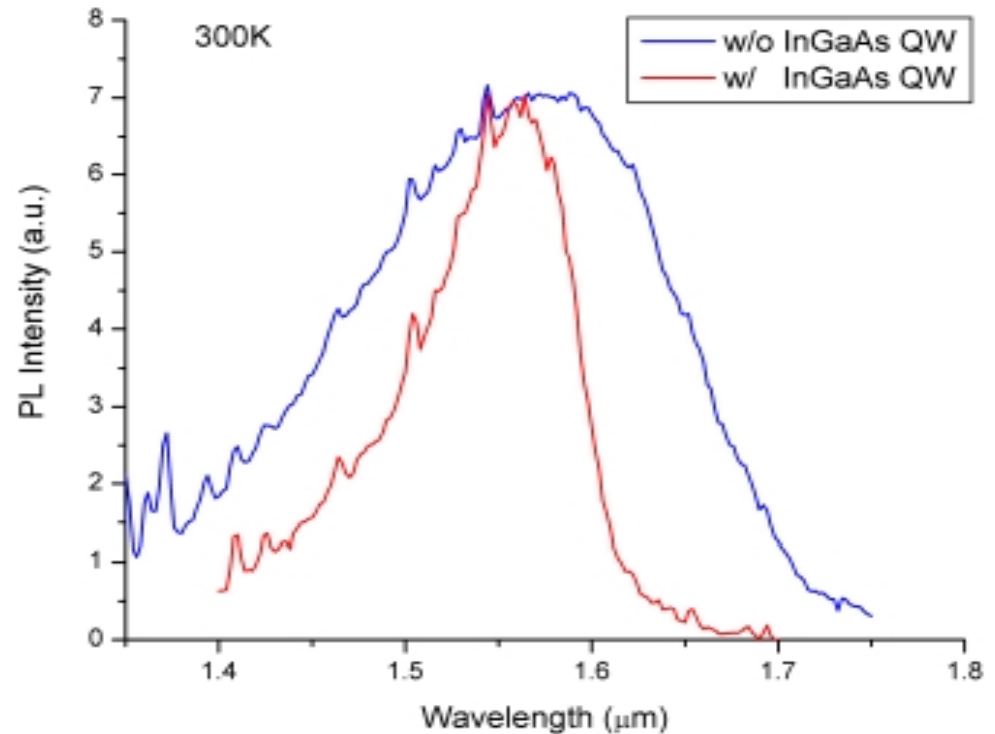
InAs QDs on InP for 1.55 μm Emission



- InAs deposition on InP
- Uniform QDs with high density
- 1.55 μm emission at 300K

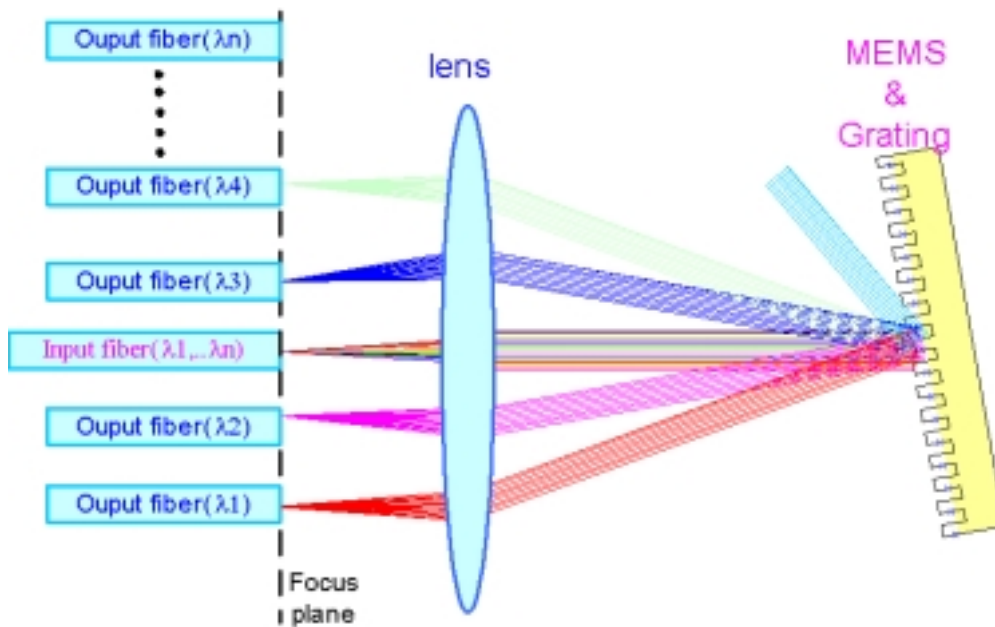
InGaAs QW Coupled InAs QDs on InP

- Photoluminescence emission in InAs QDs is selected by coupled InGaAs QW through tunneling
- Room temperature FWHM of PL spectrum decreases from 150meV to 50meV
- Useful for 1.55 μm EIT-based slow light applications.



All Optical, Wavelength-Selective 1xN Optical Switch for Multiple WDM Channels

Milton Feng, UIUC



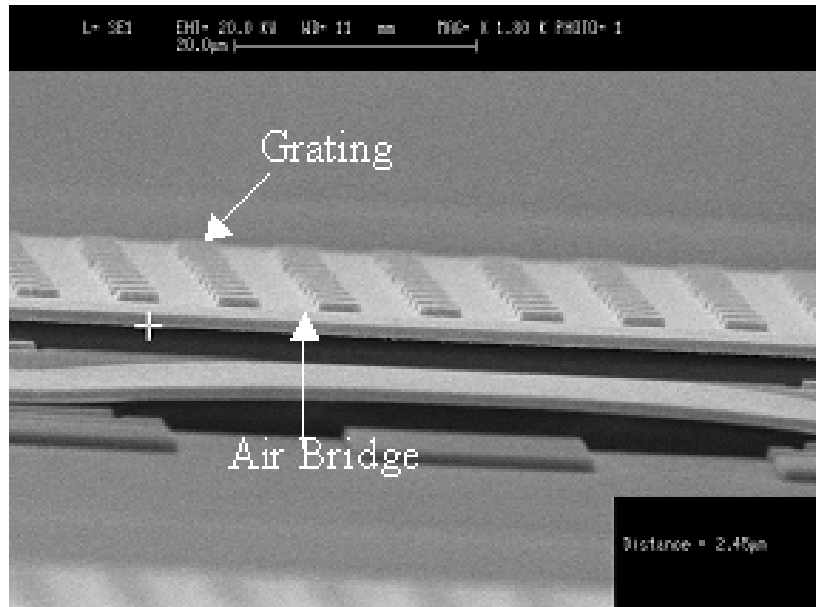
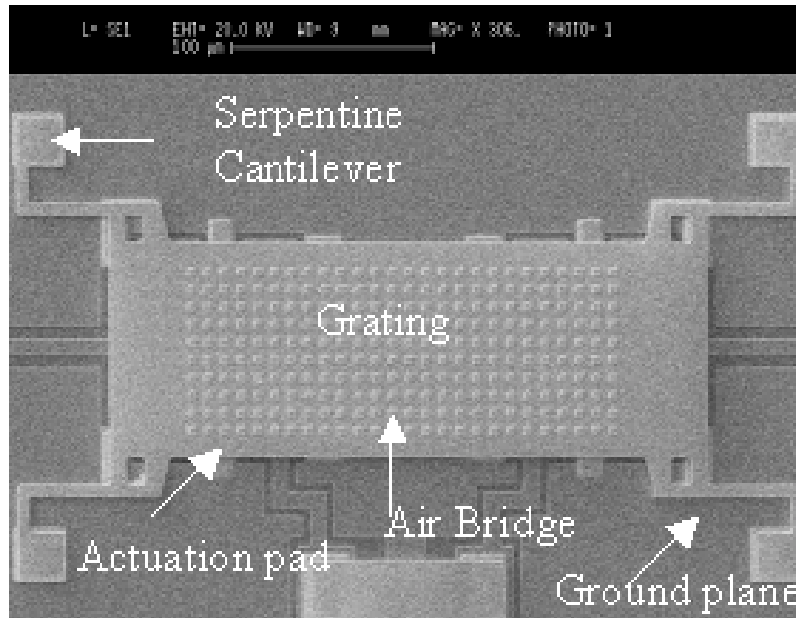
What's the advantage:

- Integration of demux, optical switch, interconnection and mux (if different wavelength light feed into the same fiber)
- Wide wavelength range (800nm-1570nm)
- Grating initial position adjust wavelength-fiber's location relationship—array and reconfigurable
- Compact, and low voltage operation

System Operation Overview:

- Input fiber has n different signals, fiber output focus plane of the lens
- Lens collimates input light
- Different wavelength reflects at different angles by the MEMS gratings (Grating equation: $\sin \theta_r = \sin \theta_i + (m\lambda/\Lambda)$)
- The same lens focus different wavelength light to pre-define location at focus plane
- Lights coupled into individual output fibers

Novel MEMS Switch and Optical Grating



SEM picture of a grating on top of MEMS air bridge. (a) Top view; (b) Side views.

- High reliability: >7 billion cold switching cycles
- (2 patents filed on the solution of sticking problems)
- Low operation voltage: < 15V actuation voltage
- Fast switching speed 21.4 ms
- Small device size: 300µm x 300µm
- Good system resolution: <10nm
- MEMS moves 5 mm (vertical) or ~2° (rotation)